beak appear to be slightly separated; it is also probable that the separation increases with the depth of the probing, although the upper and lower portions remain nearly parallel until they are thrust in to their extreme limit, when the terminal part of the upper one becomes expanded at the moment of contact with the "find."

The already overcrowded list of so-called British birds has been increased by the capture, on Fair Isle in September, 1908, of a specimen of Eversmann's warbler (*Phylloscopus borealis*). This bird, which is really a dark-coloured willow-wren, has been recorded once in Heligoland, in 1854, but its normal summer haunts are Finmark, northern Russia, and Siberia, while in winter it wanders to Burma, Malaya, and China. Fuller details of the capture will be found in the January number of Witherby's *British Birds*.

Captain Stanley Flower and his assistant, Mr. M. J. Nicoll, have drawn up a list of the species of wild birds which have been observed to visit the zoological gardens at Giza during the period between October, 1898, and October, 1908. This list, which has been published by the Egyptian Government, comprises no less than 166 species, eleven of which are, however, not indigenous to the country, and were accordingly, in all probability, represented by imported individuals. The very large number, both as regards species and individuals, which visit the establishment adds considerably to the attractions of the Giza Gardens, and the list has been published in response to inquiries from visitors as to their names. It is a prevalent idea that song-birds are lacking in Egypt, but a visit to the gardens when the nightingale and the rufous and olive warblers are singing will at once dispel this illusion.

In the report of the vertebrate section of the Yorkshire Naturalists' Union for 1908 reference is made to the appearance of a flock of Pallas's sandgrouse on the northern slope of the wolds during the autumn of that year. The great grebes on Hornsea Mere have been reduced to three, and it is believed that the diminution is mainly to be attributed to egg-collectors and other visitors. The peregrine falcons again built on Bempton Cliffs, where they reared a single young one.

The birds of the Barotsi district of the Zambesi form the subject of a paper by Mr. A. Sandberg in vol. vii., part ii., of the Proceedings of the Rhodesia Scientific Association. As an illustration of the teeming bird-life of the great valley, the author writes that "the traveller encounters enormous numbers of geese, ducks, and wading birds in wonderful variety of species, size, and coloration, and the sand-banks of the river, upon which they find a refuge, present an appearance at times which can best be described as kaleidoscopic. Above the almost deafening din of their shrill voices can be distinguished the incessant cry of the fish-eagle, for ever on the alert for prey."

PREHISTORIC ARGENTINA.[1]

THE pottery described in the first of the papers mentioned below was mainly obtained in the province of Catamarca. The specimens are illustrated by handsome coloured plates drawn from photographs. The earliest type includes bowls and jars, ornamented in white, red, and black in imitation of the woven patterns of basket-work. Similar ornamentation is found in the baskets, cloth, and pottery of New Mexico and California. Another type, with red and black colouring, shows either geometrical designs or outlines of animals, especially frogs and snakes, usually conventional in character. Among the objects depicted are the anura, *Ceratophys ornata* and *Leptodactylus ocellatus*, and the ophidia *Elaps frontalis* and *Lachesis alternatus*, as well as the rhea and puma and a fern, a species of Hymenophyllum. There are also crude representations of human beings.

The second article describes two human faces in terra-cotta, and part of the head of an animal supposed to be the coyote (*Canis cagottis*), in the same material. These were found in a high bank in the Laguna de Lobos, in the province of Buenos Aires. They are so closely similar to the earthenware "masks" found in such numbers in the ancient ruins at San Juan de Teotihuacan, in Mexico, that the author believes that they were manufactured there, but he declines to advance any theory to explain their presence in the Argentine.

The third paper deals with implements and fragments of pottery collected by Señor Carlos Ameghino on the site of a prehistoric settlement in the extreme south of the province of Buenos Aires, and distant 5 kilometres from the sea-shore. They were found on the surface at the foot of unconsolidated sand-dunes, and include flakes, scrapers, chisels, knives, arrow-heads, and grinding stones, all primitive in character. These appear to have been manufactured from ellipsoidal beach-stones, mainly jasper, though phonolite, chert, porphyritic breccia, and other materials were also employed. The grinding stones are of hard grit ("asperón").

The pottery was moulded of a sandy clay, and imperfectly baked. It was ornamented with grooves and pits made with the nail or a fragment of wood.

The collection indicates, we are told, a culture similar to that which still characterises the middle and lower parts of the basin of the Rio Negro, certain localities in the government of the Pampa, and the southern plains of the province of Mendoza. It presents many points of resemblance to that met with in the southern part of the government of the Rio Negro and in the governments of the Chubut and Santa Cruz, but differs completely from that of the rivers Salado, San Borombón and Luján, and generally the eastern portion of the province of Buenos Aires. J. W. E.

[1] (1) Alfarerías del Noroeste Argentinto (Anales del Museo de La Plata, series ii., vol. i.). Pp. 5 to 40.
(2) Sobre el Hallazgo de Alfarerias Mexicanas en la Provincia de Buenos Aires (Revista del Museo de La Plata, vol. xv., series ii., vol. ii.). Pp. 284 to 293.
(3) Arqueología de San Blas (Anales del Museo Nacional de Buenos Aires, vol. xvi. (series iii., vol. ix.). Pp. 249 to 275. All by Señor F. Outes.

THE INCREASED EXPANSION OF STEAM ATTAINABLE IN STEAM TURBINES.[1]

I FIND it difficult to add anything to the words of the many illustrious men who have addressed this society on previous anniversaries of the birth of James Watt, to the words of Sir Humphry Davy, Lord Aberdeen, and Lord Jeffrey, and in later years to those of Joule, Scott-Russell, Preece, and Kelvin. This evening I should prefer to recall to your memories the fundamental principles of steam discovered by James Watt, and to endeavour to trace their application in the engines constructed by him and by the firm of Bolton and Watt, then in the more highly developed forms of compound, triple, and quadruple reciprocating engines, and, lastly, in steam turbines on land and sea.

The laws of steam which James Watt discovered are simply these, that the latent heat is nearly constant for different pressures within the ranges used in steam engines, and that, consequently, the greater the steam pressure and the greater the range of expansion the greater will be the work obtained from a given amount of steam, and, secondly, as may be seen to us now as obvious, that steam from its expansive force will rush into a vacuum.

Having regard to the state of knowledge at the time, his conclusions appear to have been the result of close and patient reasoning by a mind endowed with extraordinary powers of insight into physical questions, and with the faculty of drawing sound practical conclusions from numerous experiments devised to throw light on the subject under investigation. His resource, courage, and devotion were extraordinary, and drew to his side a coterie of kindred spirits, with whom he discussed freely his theories and his hopes, and the results of his experiments.

In commencing his investigations on the steam engine, he soon discovered that there was a tremendous loss in the Newcomen engine which he thought might be remedied—the loss caused by condensation of the steam on the cold metal walls of the cylinder. He first commenced by lining the walls with wood, a material of low thermal conductivity. Though this improved matters, he was not satisfied; his intuition doubtless told him that there should

[1] The James Watt lecture delivered at Greenock by the Hon. C. A. Parsons, F.R.S.

be some better solution of the problem, and doubtless he made many experiments before he realised the true solution in a condenser separate from the cylinder of the engine. It is easy after discovery to say how obvious and how simple, but many of us here know how difficult is any step of advance when shrouded by unknown surroundings, and I can well appreciate the courage and the amount of investigation necessary before James Watt thought himself justified in trying the separate condenser.

But to us now, and to the youngest student who knows the laws of steam as formulated by Carnot, Joule, and Kelvin, the separate condenser is the obvious means of constructing an economical condensing engine.

Watt's experiments led him to a clear view of the great importance of securing as much expansion as possible in his engines. The materials and appliances for boiler construction were at that time so undeveloped that steam pressures were practically limited to a few pounds above atmospheric pressure. The cylinders and pistons of his engines were not constructed with the facility and accuracy with which we are now accustomed, and chiefly for these reasons expansion ratios of from two- to three-fold were the usual practice. Watt had given to the world an engine which consumed from five to seven pounds of coal per horse-power hour, or one-quarter of the fuel previously used by any engine. With this consumption of fuel its field under the conditions prevailing at the time was practically unlimited. What need was there, therefore, for commercial reasons, to endeavour still further to improve the engine at the risk of encountering fresh difficulties and greater commercial embarrassments? The course was rather for him and his partners to devote all their energy to extend the adoption of the engine as it stood, and this they did; and to the Watt engine consuming from five to seven pounds of coal per horse-power mankind owes the greatest permanent advances in material welfare recorded in history.

The Watt engine, with secondary modifications, was the prime mover in most general use for eighty years until the middle of the last century, when the compound engine began to be introduced. Why, we may inquire, was it that the compound engine was so long in coming into use, for it had been patented by Hornblower in 1781, or seventy years before? and why does John Bourne in his large book, "Practical Instructions for the Manufacture and Management of every Species of Engine," published 1872, make no mention in the index of the compound or triple expansions, and when he speaks of Hornblower's double-cylinder engine (really a compound engine) does he do so in disparaging terms, mentioning that there was no increased economy in steam over the single cylinder? This last statement provides an answer to our inquiry, for it is orrect in view of the very low steam pressure in general use before that time, or until somewhat before the middle of the last century, when the introduction of the locomotive led to a general rise in pressures on land, and the surface condenser some years later to increased steam pressure at sea. Also, we must remember that many experiments have shown that unless the mean difference of pressure on a piston exceeds about 7 lb. per sq. inch, the friction, the bulk, the momentum of the moving parts, and the cost make such a cylinder not worth having. The case, however, with the turbine is entirely different, and it is chiefly owing to this difference and to its power of usefully expanding the steam down to the very lowest vapour pressure attainable in the best condenser that it has surpassed the best reciprocating engines in economy of steam. To return to our subject. The introduction of the compound, triple, and quadruple expansion engines was therefore concurrent with the improvements in boiler construction, the introduction of the surface condenser, and the general rise in steam pressure, and by the quadruple engine the expansion ratio has been extended up to about sixteen-fold, and the consumption of coal per horse-power reduced to from $1\frac{1}{4}$ lb. to $1\frac{1}{2}$ lb. per horse-power hour, or to from one-fourth to one-third the fuel consumed in the time of James Watt. Let us now direct our attention to the turbine engine, which derives its power, not from the pressure of the steam on a piston, but from the momentum of the steam at high velocity curving around and blowing forward the vanes or paddles attached to the shaft.

It is unnecessary here to recapitulate the many attempts to construct a successful steam turbine from the days of Hero until a quarter of a century ago, as several excellent books are now published on the subject. It is true that the difficulties of construction and inferior workmanship available during this early period were a serious bar to progress, but the chief bar to progress lay in the fact that the turbine, to be economical in steam, must (at least in its primitive form) rotate at a very high speed, and that before 1880 there was no commercial use for such a high-speed engine excepting through the intermediary of belts or friction gearing, or for such exceptional purposes as the direct driving of circular saws. The chief purpose for which turbines are now extensively used on land did not then exist, namely, for the driving of dynamos. Then, again, belts for high speeds are a very unsatisfactory appliance, and accurately cut spiral gearing as recently introduced by Dr. de Laval had not been devised; and, again, the problem of applying a turbine to the propulsion of vessels being surrounded, as it was, with great consequential difficulties would naturally only be attacked after the successful application of the prime mover to some easier and simpler purpose on land, so that I think, on the whole, we may safely say that under the conditions prevailing the commercial introduction of the turbine before 1880 was a practical impossibility.

It is a matter of history that the turbine principle had been used for obtaining power from waterfalls before the days of James Watt, but I am not clear that he had in mind any concrete form of steam turbine; yet in 1770 he suggested "a circular engine consisting of a right-handed and left-handed bottle-screw spiral involved in one another," and he also appears to have had a leaning towards some form of directly rotary engine, for in 1769 he took a patent for a Barker's reaction water-wheel, the water pressure being derived from the action of steam on water, as in Savery's fire-engine or a modern pulsometer. He also designed a rotary abutment engine in 1782, but in none of these machines is there any indication of an attempt to gain greater expansion ratios for the steam.

It is peculiarly interesting to recall on this occasion that one of the earliest steam turbines to be put to practical work was in this town; it was about the middle of the last century, and was a turbine like that described by Branca in 1629. It consisted of a steam jet playing upon a paddle-wheel, coupled to a circular saw, which it drove for some years. The principle of the expansive working of steam was, however, only to a small extent utilised in this engine, for I believe that the steam jet was non-divergent, which implies a useful expansion ratio of only about $1\frac{1}{2}$-fold. One of the most conspicuous workers in the design of the compound turbine was Robert Wilson, of Greenock, Master of Arts of Edinburgh, who lodged a patent in 1848. This patent was of unusual length and wealth of detail, and describes radial-flow and parallel-flow compound turbines, designed for moderate ratios of expansion. The blades and guides were proposed to be fastened by casting them into the hub and case, a method occasionally used at the present time.

The principles of Wilson's design are generally correct, but the proportions of his turbines are extravagantly incorrect, the blades being too large and too few for success. I had a model made of Wilson's turbine eighteen years ago, and under steam all that could be said was that it went round the right way. I do not think that Wilson can have made a model and tested it before he applied for his patent, the course followed by James Watt, and one which is to be strongly recommended to the attention of inventors generally in almost all circumstances, as saving time, money, and disappointment. There have been many workers on steam turbines of English nationality before and since the time of Wilson, but within the last twenty years other countries have taken up the subject with zest.

Prior to 1880 the uses for a very high-speed motor were few, as we have seen; the speed of revolution of steam wheels, as Bourne described them in 1872, "was inconveniently high for most purposes," but after 1880 conditions were changed; the beautiful machine, the milk separator, of Dr. de Laval, of Stockholm, and the great invention of the dynamo electric machine had come, and

required a high-speed prime mover to drive them, and these provided encouragement to the workers on steam turbines; thus between 1884 and 1888 we find the practical and successful realisation in altered and correct proportions of ideas and suggestions of previous workers, the compound steam turbine in 1884 applied to the direct driving of dynamos, and the single-stage impulse wheel in 1888, of very high velocity, played upon by the expanding steam jet, both types possessing great ratios of expansion.

All steam turbines now in practical use expand the steam usefully over nearly the whole range from the boiler pressure to the pressure in the condenser, and their designs are based on the principles involved in the construction of their prototypes of 1884 and 1888.

There is, first, the compound turbine, the characteristic feature of which is the gradual expansion of the steam by small drops of pressure at each turbine of a long series of turbines of gradually increasing volumetric capacity, as in the Parsons, or a somewhat less gradual expansion with greater drops of pressure at each stage, as in the Rateau, Zoelly, and others.

Then there is the expansion by the divergent jet in one stage, as in the de Laval, or an expansion in a relatively small number of stages by expanding jets playing upon rows of buckets with intermediate rows of reaction guides, as in the Curtis and Reidler-Stumpf.

Then there are combinations of the first and second, where the first stage of the expansion is affected by, say, a Curtis element, and the rest by a Parsons, and many other combinations have also been proposed, too numerous to mention here.

Let us consider these principal examples of the turbine principle more closely. In the compound turbine the velocities of the steam are low; at each passage through the blades it expands a little, yet it obeys, as regards the velocity of efflux, approximately the laws of flow of fluids; but the aggregate of the small expansions soon becomes apparent, and has to be taken into account when reckoned over a considerable number of the series of elemental turbines. For instance, if the expansion ratio for a single turbine of the series be as 1 to 1·03 in volume, a 3 per cent. expansion, then after passing through twenty-three turbines its volume will be doubled, and the velocity of flow through the guide blades and moving blades (presuming they are of equal area of passage way) will be about 230 feet per second. The velocity of the blades is, generally speaking, about half the velocity of the steam at issue, and will therefore, in this case (which I have taken as common in marine practice), be about 115 feet per second.

The difference in velocity of the steam and the blades is smoothed over largely by the curvature of the blade, which somewhat resembles a shallow hook around which the stream lines in the steam arrange themselves with very little shock or eddying in the steam, so that the coefficient of efficiency is high.

In turbines for driving dynamos and other purposes where higher speeds of revolution are permissible, steam velocities up to 600 feet and blade velocities up to 300 feet per second at the exhaust ends are general.

In turbines of the Rateau, Zoelly, and other types with multiple discs, each disc carries one row of blades only, and works in a cell, through the walls of which the shaft passes in a steam-packed gland; nearly the whole drop in pressure takes place at the guide vanes, and very little at the moving vanes, which are of cup form; the velocities of the steam generally range from 900 feet to 1100 feet per second, and the velocities of the blades from 350 feet to 450 feet per second. In turbines, however, of the de Laval single-wheel and of the Curtis and other types with a relatively small number of pressure stages, higher steam velocities are used, ranging from 4200 feet per second in the single-wheel down to 1500 feet in a seven-stage Curtis turbine. The jets used in the single-stage turbine are of very divergent form, but when the expansion is divided over seven stages very little divergence is necessary.

In the single-stage turbine, blade velocities so high as 1200 feet per second are adopted, the discs being of taper form and of the strongest nickel-steel; but even this high velocity is insufficient to obtain a very good coefficient of efficiency from the steam, and when the disc is made large, so as to reduce the immense angular velocity incidental to the high peripheral speed, the skin friction of the disc and the prime cost and weight increase rapidly.

In the Curtis five-stage the blade velocities are about 400 feet per second, and the steam velocity about 2000 feet per second, and by the passage of the steam through two rows of moving and one row of guide blades between them at each wheel the steam is brought nearly to rest before passing on to the next succeeding chamber, and by this sinuous treatment of the steam efficiencies are obtained comparable to those of the compound turbine.

From the commencement of turbine design in 1884 I have avoided the adoption of high steam velocities on account of their cutting action on metals when any water is present. The cutting has been found to be due, not to the impact of gaseous steam, but to that of minute drops of water entrained by the steam, and hurled by it against the surfaces. The drops, formed like fog, consequent on the expansion of saturated steam, are sufficiently large to cause the erosion. To test the effect in an extreme case, a hard file was placed opposite to a jet of steam issuing at 100-lb. pressure into a vacuum of 1 lb. absolute pressure; in 145 hours it was found to be eroded to the extent of about 1/32 inch, as if it had been sand-blasted. The calculated velocity of the issuing steam in this case is about 3800 feet per second, and the striking fluid pressure of a drop of pure water at this velocity about ninety tons per square inch. Owing, however, to the receding velocity of the blades from the blast in all turbines, the erosive effect is much reduced. In multicellular turbines of few stages, though the erosion is slow, yet provision is necessary for renewal of blades at intervals. In turbines of many stages it is still slower, and in the compound turbine erosion is, practically speaking, absent, and renewal of blades unnecessary. This absence of the tendency to erosion in compound turbines permits the use of brass or copper blades, which are found to preserve their polish and are not liable to corrosion or rusting, and preserve their smoothness of surface and the initial economy of the engine unimpaired for many years.

It is now just fifteen years ago, and exactly ten years from the commencement of work on the compound steam turbine, that the results obtained on land were thought to justify an attempt to apply the turbine principle to the propulsion of vessels. These results lay in the fact that a condensing turbine engine of 200 horse-power, with an expansion ratio of 90 volumes, had been found to have equal economy to a good compound piston engine, and that, besides, there were within sight reasons to hope for still better results. A commencement was made, and by the end of 1897, after three years of hard work and experiment, the *Turbinia* was completed. Her trials were usually made on the measured mile in the North Sea, but occasionally, when the sea was too rough, runs at speeds up to 31 knots were made on the Tyne, where the legal limit of speed of steamships was 7 knots, and by the magnanimity of the Tyne Improvement Commissioners the completion of the *Turbinia* was greatly facilitated, though it is fair to say great care was exercised and no harm done to the public. In her the problem of adapting the turbine to the screw propeller was worked out. The result was a compromise between the two. The turbine had to be made short and broad, so as to revolve as slowly as possible, and the screw had to be made with finer pitch and wider blades. The result in propulsive efficiency was found to be good, and the problem satisfactorily solved for fast vessels of 16 knots and upwards, and it was also seen that the faster the vessel the more favourable would be the economy of the turbine as compared with the reciprocating engine.

The destroyers *Viper* and *Cobra* followed. The next step was the application of the turbine to vessels of commerce.

Dumbarton was the scene of many conferences. Mr. Archibald Denny was deeply interested in the problem, and so was Captain John Williamson, with the result that the first passenger vessel, the *King Edward*, was built in 1901 at Dumbarton to the joint ownership of Captain John Williamson, Messrs. Denny, and the Parsons Marine

Steam Turbine Co., Ltd. The success of this vessel soon led to the adoption of turbines in cross-Channel steamers, and also led, aided by the success of the destroyers *Viper* and *Velox*, to the specification of turbines in H.M.S. third-class cruiser *Amethyst*, and from that time turbines began to be rapidly adopted for fast vessels, including the largest and fastest mercantile and war vessels afloat.

The success of the *King Edward* in 1901 was a red-letter day for the marine turbine. Let us inquire in what this success consisted. In the first place, a factor of primary importance is the coal bill, and it was soon proved by Messrs. Denny that this was less to the extent of from 15 per cent. to 25 per cent. than with vessels propelled by reciprocating engines of equal displacement and carrying capacity. Also the cost of oil, which with reciprocating engines amounts to about 5 per cent. of the coal bill, was nearly eliminated; the vibration was also less. Then the upkeep of machinery was found to be favourable, and as the crew became accustomed to her the coal consumption still further diminished, and I am informed by Captain Williamson that this further decrease has been well maintained up to the present time. The exceptional trustworthiness of the machinery also became more and more assured.

There are now about 120 vessels actually on service fitted with turbines, and seventy more under construction, representing a total horse-power of marine turbine engines of about 2,250,000, of which 1,250,000 horse-power is completed.

There were two other great steps in the adoption of the turbine, which occurred almost simultaneously in 1905, namely, the decision of the Admiralty to adopt turbines for all new construction in fighting ships, and the adoption of turbine machinery for the great Cunarders. The steps from the second-class cruiser *Amethyst*, of 15,000 horse-power, to the *Dreadnought*, of 22,000 horse-power, and to the *Indomitable*, of 41,000 horse-power, were, it is true, gradual, but the number of vessels involved was great. In the mercantile marine the step from the *Queen*, the first cross-Channel vessel, of 8000 horse-power, directly to the *Lusitania* and *Mauretania*, of 70,000 horse-power, required great courage on the part of the late Lord Inverclyde and his co-directors and engineers. Such steps as these are not taken without thorough investigation based on ascertained results. When it is considered that the low-pressure turbine in the *Queen* was 6 feet in diameter, 20 feet in length, and 25 tons in weight, as compared with the Cunarders' low-pressure turbines of about 17 feet 6 inches diameter, 50 feet in length, and 300 tons weight, it is realised what a great departure was involved; forces and conditions were altered; differential expansions and deflections of the structure had all to be re-considered in detail, for though they had been successfully dealt with and controlled in the smaller engine, the magnitude of the larger structure rendered re-calculations and thorough investigation necessary; thus no room was left for the possibility of any adverse conditions arising, due to the very great increase in the size of structure, and everything that care, thought, and experience could accomplish was done, and the results have satisfactorily agreed with the hopes and estimates of all concerned.

In the *King Edward* there was a great increase in the ratio of expansion beyond that hitherto realised in any reciprocating engine. Her boiler pressure is 150 lb., and the pressure at the inlet to the turbines at normal full speed 130 lb.; the pressure in the condenser is $1\frac{1}{2}$ lb. absolute, a ratio of 87 by pressure or about 66 by volume, as compared with the volumetric ratio of about 10 in triple-expansion reciprocating engines for a similar class of vessel.

In some later turbine vessels higher steam pressures have been adopted, resulting in a small gain in efficiency, partly counterbalanced by the greater weight of the turbine cases, and if the vessel has Scotch boilers, then also by the greater weight of the boilers to carry the greater pressure; and on the whole the net gain, if any, is but small.

A substantial increase in efficiency has, however, been realised by improvements in condensers and pumps, in order to take full advantage of the property of the turbine of expanding steam usefully to the lowest pressure attainable in the condenser. Before the turbine came into use a very high vacuum was not found desirable, for the simple reason that the reciprocating engine is unable to utilise it. For instance, a triple-expansion engine does not gain in economy of coal if the absolute pressure in the condenser be diminished below $2\frac{1}{2}$ lb. The turbine, however, derives a net gain in efficiency of 13 per cent. from a diminution of pressure in the condenser from $2\frac{1}{2}$ lb. absolute to 1 lb. absolute.

The improvements that have been introduced of late years in condensing plants consist primarily in improved design of the condenser and in improvements in air pumps to increase their volumetric capacity. In the condenser the tubes are so spaced and grouped that the steam, attenuated into relatively an enormous volume, shall pass freely without much resistance and drop of pressure throughout the whole surface, and provision is made by the form of the condenser shell, with or without a single baffle plate, so that the suction of the air pump shall remove the air uniformly from all parts. The vacuum now usually obtained in well-equipped turbine vessels is very close to that corresponding to the temperature of the circulating water leaving the condenser. The difference is sometimes so small as two degrees, so that there is no room for much further improvement in this direction. To increase the volumetric capacity of the air pumps, dry air pumps run at a high speed may be used, separate pumps being employed to remove the water of condensation. An alternative, and perhaps a preferable method, is the vacuum augmenter, a simple apparatus without moving machinery, which consists of a very small steam jet placed in a narrowed portion of the ordinary air-pump suction, which sucks the air out of the condenser and compresses it through a small intermediate cooler into the suction of the air pump, the water of condensation draining by gravity through a water seal into the same air-pump suction.

Further possible improvements would therefore seem to tend in the direction of an increase in the efficiency of the turbine itself. In large turbine vessels the ratio of the shaft horse-power to the total available energy in the steam from boiler to condenser reaches 70 per cent., and the question is whether there is a probability of somewhat reducing this loss of 30 per cent.

During the last eleven years a small reduction in steam per horse-power delivered to the shaft has been brought about by minor improvements in design, better finish and proportion of the blading, and by the increased size of the engine constructed.

In 1897 the *Turbinia* consumed 16 lb. per shaft horse-power for all purposes; in 1901 the *King Edward* consumed 16 lb. per shaft horse-power for all purposes; in 1907 the *Lusitania* consumed 12 lb. per shaft horse-power for all purposes; and the *Mauretania* consumed 11·5 lb. per shaft horse-power for all purposes.

In the case of slow vessels, where the exigencies of the screw propeller limit the revolutions to a low rate, I have for many years advocated a combination or partnership between the reciprocating engine and the turbine which seemed to promise a high degree of efficiency and to suit all the requirements of the case. In this combination each engine deals with that part of the expansion for which it is best suited, the reciprocating engine taking the high-pressure portion from the boiler pressure down to about atmospheric pressure, and the turbine carrying on the expansion from about atmospheric pressure right down to the condenser pressure.

The reciprocating engine is thus relieved of the low-pressure part of the expansion, which at best it carries out in a very inefficient manner, losing as it does all the last part, and the turbine is relieved from the high-pressure part, which when constructed for slow revolutions it performs unsatisfactorily; but the turbine designed for low pressures and slow revolutions is an engine which converts a very high percentage of the power in the steam into shaft horse-power.

Messrs. Denny have fitted the *Otaki*, of 8000 tons, 5000 horse-power, and 13 knots sea speed, with this system, the boiler pressure being 200 lb., no superheaters being fitted, and the very low consumption of 12·3 lb. of steam for all purposes was registered on trial. Messrs. Harland and Wolff are also fitting a vessel for the Dominion Line on this system.

James Watt, we are told, suggested the screw propeller in 1770; half a century later it commenced to come into use, and now it is almost universally adopted in all new construction.

It is a very interesting and curious fact to note that in the first instance, and for many years, the screw was driven by spur gearing from a very slow-speed engine, presumably because the builders of engines were afraid to design the engines to run so fast as the screw required to be driven. Now for forty years or more gearing has been entirely abandoned, and the high-speed reciprocating engine has worked well.

The turbine has now come on the scene, and its best speed of revolutions is faster than that of the screw, excepting in fast vessels; for the larger portion of the tonnage of the world it is at present unsuited, except to take a secondary but excellent part in the combination system.

We may naturally speculate as to the future, and inquire if there is a possibility of the turbine being constructed to run more slowly and without loss of economy, or whether the propeller can be modified to allow of higher speed of revolution.

Or, again, may a solution be found in reverting to some description of gearing, not to the primitive wooden spur gearing of half a century ago, but to steel gearing cut by modern machinery with extreme accuracy and running in an oil bath, helical tooth gearing or chain gearing, or, again, some form of electrical or hydraulic gearing?

These are questions which are receiving attention in some quarters at the present time, and if a satisfactory solution can be found, then the field of the turbine at sea will be further extended.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—It is proposed to confer the honorary degree of Sc.D. on Dr. Sven Hedin on Thursday, March 4. Dr. Sven Hedin will lecture before the Senate on that date in the Senate House. Before the ceremony he will be entertained at lunch by the master and fellows of Gonville and Caius College.

The Isaac Newton studentship, tenable from April 15, 1909, to April 15, 1812, has been awarded to Mr. W. J. Harrison, of Clare College.

The Lowndean professor, Sir Robert Ball, F.R.S., will lecture on "Ancient and Modern Views of the Constitution of the Milky Way" before the Cambridge Antiquarian Society on Monday, March 1, at 4.30 p.m.

In July of last year letters signed by the Chancellor were sent to more than 300 universities, colleges, academies, and other corporate bodies, inviting them to appoint delegates to attend the Darwin celebration from June 22–24 next. In answer to these invitations more than 200 delegates have been appointed. The expense likely to be incurred in carrying out the programme amounts to considerably more than 500*l.*, but it is hoped that it may be possible to provide the excess above that sum by private subscriptions, and the Senate will therefore not be asked to authorise the expenditure of more than 500*l.* from the University chest.

MR. E. C. WILLS has given 10,000*l.* to the Bristol University Fund, thus raising the fund to practically 200,000*l.*

WE learn from a recent number of *Science* that Mrs. E. G. Hood has given the University of Pennsylvania 20,000*l.* to establish graduate fellowships in the law department. Mr. Adolphus Busch, who last August promised to contribute 10,000*l.* towards the 60,000*l.* necessary for the erection of the new building for the Germanic Museum at Harvard University, has increased his gift to 20,000*l.* The General Education Board has offered to give Bryn Mawr College 50,000*l.* on condition that friends of the college subscribe 56,000*l.* by June, 1910. This is in addition to the 20,000*l.* recently given by the alumnæ Of this sum, 26,000*l.* is to be used to pay the debt of the college, and the balance is to be reserved as an endowment fund.

A ROYAL COMMISSION has been appointed to consider the position and organisation of university education in London. The terms of the reference to the commission are:—to inquire into the working of the present organisation of the University of London, and into other facilities for advanced education (general, professional, and technical) existing in London for persons of either sex above secondary-school age; to consider what provision should exist in the metropolis for university teaching and research; to make recommendations as to the relations which should in consequence subsist between the University of London, its incorporated colleges, the Imperial College of Science and Technology, the other schools of the University, and the various public institutions and bodies concerned; and further to recommend as to any changes of constitution and organisation which appear desirable. In considering these matters, regard should also be had to the facilities for education and research which the metropolis should afford for specialist and advanced students in connection with the provision existing in other parts of the United Kingdom and of His Majesty's dominions beyond the seas. The chairman of the commission is Mr. R. B. Haldane, K.C., M.P., and the other members are Viscount Milner, G.C.B., G.C.M.G., Sir Robert Romer, G.C.B., Sir R. L. Morant, K.C.B., Mr. Laurence Currie, Dr. W. S. M'Cormick, Mr. E. B. Sargant, and Mrs. Creighton. The joint secretaries are Mr. J. Kemp and Dr. H. F. Heath.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, January 28.—Mr. A B. Kempe, treasurer, in the chair.—The action of the venom of *Sepedon haemachates* of South Africa: Sir T. R. **Fraser** and Dr. J. A. **Gunn.**—The colours and pigments of flowers, with special reference to genetics: Miss M. **Wheldale.** The communication gives an account of investigations made upon plant pigments, with a view to the elucidation of phenomena observed in the genetics of flower-colour. A primary classification is made into plastid pigments and pigments soluble in the cell-sap. Of the former, several kinds are shown to exist, in addition to carotin and xanthin. When the type of a species contains more than one plastid pigment, the power to produce each pigment is expressible as a Mendelian factor. Loss of the factors in turn gives rise to varieties of the type. Soluble pigments are classified as red-purple-blue (anthocyanin) and yellow (xantheïn) and of both; various kinds can be differentiated by means of chemical reagents. There is evidence, moreover, of a relationship between the behaviour of the pigments in genetics and their chemical reactions. Colourless tannin or glucoside-like substances are found to be widely distributed in plants, and such substances appear to take part in the formation of some kinds of anthocyanin. This conclusion is based upon examination of pigments of varieties of *Antirrhinum majus*, of which the inheritance of flower-colour has been worked out by the author (previous communication to Roy. Soc.); the results of the present paper show that in this genus both a glucoside-like substance and a reddening factor are essential to the production of anthocyanin of the type. Loss of glucoside gives rise to an albino variety still capable of carrying the reddening factor; loss of the reddening factor gives a variety bearing ivory-white flowers, distinguishable from the albino, and containing the glucoside. Experiments on the same genus further indicate that the xantheïc pigment of a yellow variety is a derivative of the glucoside of the ivory-white, to which it is also hypostatic. Examples are given of genera resembling Antirrhinum in their series of varieties derived from the anthocyanic type, and also of genera forming another series, from which the xantheïc variety is absent. In this connection, stress is laid upon the conception of two forms of albinism, one due to loss of anthocyanin only, the other to loss of both anthocyanin and xantheïn.—The variations in the pressure and composition of the blood in cholera, and their bearing on the success of hypertonic saline transfusion in its treatment: Prof. L. **Rogers.** This communication contains some points of